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DEVELOPMENT OF AN ASSESSMENT FRAMEWORK FOR STUDENT ENGAGEMENT IN DESIGN THINKING PROJECTS FOR HEALTH INNOVATION

by

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Abstract

Student engagement is a dynamic and multifaceted concept – it encompasses physical, emotional, and cognitive components. Various instruments to assess student engagement exist, however these are not intended to assess how students engage with one another and with community stakeholders in participatory health projects. Although instruments do exist to assess participation/power-sharing in participatory health projects, none of the available instruments are suitable for the assessment of student engagement in such projects.

The current study set out to develop an assessment framework for student engagement in design thinking projects for health innovation. Design thinking is a human-centred and participatory approach to problem-solving. The objectives of the project were: (1) the design and implementation of a questionnaire to assess student engagement in design thinking activities, and (2) assessment of the validity of the questionnaire. A preliminary questionnaire was developed with the aid of the literature and implemented for students taking a postgraduate course called Health Innovation & Design, which follows a design thinking approach for health innovation. Analysis of students' written reflective reports and a focus group discussion were used to revise the questionnaire items. The revised questionnaire was validated by design thinking practitioners (the course lecturer and facilitators), and further modifications were made based on their views.

The assessment framework developed in this study incorporates the design thinking phases according to the IDEO design thinking approach, an educational definition of student engagement, and recommendations by students of the Health Innovation & Design course and their course lecturer and facilitators. This questionnaire may be used to assess engagement in academic settings as well as non-academic settings when design thinking is applied for health innovation.

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1 Introduction

Community-engaged scholarship encompasses various forms of community-academic partnership. This is in line with the Alma Ata Declaration, which promotes such partnerships (World Health Organization, 1978). In these partnerships, the effective involvement of all stakeholders is crucial to foster true empowerment (Rifkin, 2014), so that community members have the power to influence decisions and the capacity to engage effectively with those decisions (Reed, 2008). A number of typologies of community-academic partnership have been developed, which are based on a continuum of power sharing.

In community-academic partnerships students may be involved in a variety of activities that draw on their physical presence and cognitive input. An example of a such a partnership is that between a postgraduate programme in health innovation and community organisations, with the application of design thinking for teaching and learning activities (Conrad et al., 2019, Saidi et al., 2019). By applying design thinking for pedagogy, students are provided with an opportunity to interact with community stakeholders to understand their "real-life" challenges and to subsequently develop solutions towards social change. Design thinking is a human-centred and participatory approach that may be used in scientific and technological projects that aim to generate social, economic and political impact (Ferreira et al., 2015). It is used to support the design of innovations in a course called Health Innovation & Design that forms part of the MPhil programme in Health Innovation and the MSc programme in Biomedical Engineering at the University of Cape Town (UCT).

Assessment of participation in community-engaged projects may provide valuable insights on programme outcomes, the characteristics of successful experiences and an understanding of how things happened during the project (Draper, Hewitt & Rifkin, 2010). Various tools have been developed for such an assessment. To assess community-academic partnerships, it is critical to understand the nuances in the terminology used to describe these partnerships. Terms typically used are participation and engagement – broadly, participation refers to physical contribution (Barki & Hartwick, 1994), while engagement is more complex and incorporates elements of physical, emotional, and cognitive energy that is invested (Axelson & Flick, 2010).

An assessment of student engagement in the design thinking implementation of the Health Innovation & Design course at UCT, would be useful to inform curriculum development. Recently, an adapted framework to assess stakeholder participation has been proposed for projects that use design thinking for health innovation (Hendricks et al., 2018). This

assessment framework, however, is not targeted at assessing student engagement. In addition, the framework only considers the physical aspect of engagement i.e. participation. Assessment tools are not available for student engagement in design thinking when it is employed as a pedagogical tool for health innovation. This dissertation presents the development of a framework to assess the engagement of students as stakeholders in a design thinking project for health innovation. The assessment framework that has been developed can be used to understand the phenomenon of student engagement in participatory health projects, where community stakeholders are involved.

1.1 Aims and Objectives

The aim of this study was to develop a framework to holistically assess student engagement in a course that uses a design thinking approach, in partnership with communities, for health innovation.

The aim was achieved through the following objectives:

1. Designing and implementing a questionnaire to assess student engagement in design thinking activities.
2. Assessing the validity of the questionnaire.

1.2 Overview of the dissertation

Chapter 2 presents a literature review focused on stakeholder engagement and assessment in health projects. Chapter 3 presents the methods followed to achieve the aim and objectives, namely development of questionnaire items, assessment of responses and written reports, a focus group, and practitioner validation. Chapter 4 presents the study results. Chapter 5 presents a discussion of the findings of the study, along with study limitations, recommendations and concluding remarks.

2 Literature review

The Alma Ata Declaration of the World Health Organization (WHO) encourages stakeholder participation in planning, organization, operation, and control of healthcare solutions towards effectiveness and sustainability (World Health Organization, 1978). Stakeholders in this instance may include key role players such as healthcare workers, community members, and representatives of the health system. Effective partnerships between academia and the public as stakeholders are valuable in the drive towards attainment of health (Rifkin, 2014). These partnerships are characterized by power-sharing, or the inclusion of the public in the research process. While the core principle of these partnerships is to involve the public, the participation itself can vary between minimal inclusion of the public in the process, to collaborative involvement (Goodman et al., 2017).

Engagement is a complex and dynamic phenomenon (Korhonen et al., 2019, Rifkin, 2014). To understand its dynamics, it is useful to assess it. While health research that is participatory has become valued as an effective strategy to improve user conditions and reduce disparities (Goodman et al., 2017), evidence of the success of health programmes as a direct consequence of participation is limited (Draper, Hewitt & Rifkin, 2010, Hossain et al., 2004).

This literature review explores engagement in participatory health projects, the role of students in these projects and in health educational activities including design thinking, and the methods through which engagement, student engagement, and student engagement in design thinking can be assessed.

The definitions of community participation or engagement are not consistent (Popay et al., 2007:20, Rifkin, 2014). This inconsistency is a result of the lack of agreement amongst community engagement researchers about the related terminology (i.e. community, participation, engagement) that is often used (Popay et al., 2007:20). Rifkin (2014) further states that when links between the terms can be found, the context specificity of the terminology prohibits generalisability. *Participation* can be defined as taking part or contributing to something; it may be formal in the case of a formal meeting, or informal in the form of a casual discussion, and performed individually or in a group (Barki & Hartwick, 1994). *Engagement* on the other hand refers to how involved or interested one is in an experience beyond the mechanisms of contribution; it considers the physical and psychological energy that is invested and how this influences learning experiences (Axelson & Flick, 2010).

2.1 Assessment of engagement

A set of instruments are available for the assessment of power sharing in participatory research (Arnstein, 1969, Draper, Hewitt & Rifkin, 2010, Rifkin, Muller & Bichmann, 1988).

To assess levels of participation in a community-engaged project – or "the extent of citizen power" – Arnstein (1969) uses a Ladder of Citizen Participation, on which the two lowest rungs, Manipulation-Therapy, and rungs three to five, Informing-Consultation-Placation, describe "non-participation" and "degrees of tokenism," respectively, while the three topmost rungs, Partnership-Delegated Power-Citizen Control, illustrate "degrees of citizen power" in which the community has the majority in decision-making. Similar models assessing power sharing were later developed. Rifkin, Muller & Bichmann (1988) use a continuum, with *wide participation* (communities are key role players with professionals acting as resources) on one end and *narrow participation* (professionals are decision-makers) on the other. Draper, Hewitt & Rifkin (2010) modified this continuum by replacing wide participation with *empowerment* and narrow participation with *information sharing*.

These instruments can be used to assess levels of participation amongst and between stakeholders in a participatory project. Indicators of power dynamics can be specified according to project imperatives. The indicators, or dimensions, used by Barker & Klopper (2007) (Needs Assessment, Management, Organisation, Resources, and Leadership) are similar to those used by Rifkin, Muller & Bichmann (1988) (Needs Assessment, Management, Organisation, Resource Mobilisation, and Leadership) and Baatiema et al. (2013) (Needs Assessment, Management, Organisation, Resource Mobilisation, and Leadership). These differ from those used by Naylora et al. (2002) (Identification of Need, Defining goals, Mobilizing Resources, Methodology, Indicators of Success, Sustainability) and Draper, Hewitt & Rifkin (2010) (Leadership, Planning and Management, Women's Involvement, External Resources, Monitoring and Evaluation). Each of these dimensions can be assigned a rating scale on which stakeholders rate levels of engagement.

To assess participation in design thinking projects, Hendricks et al. (2018) have developed an assessment framework based on the above methods. This framework utilizes semi-structured interviews with questions that are specific to each phase of the design thinking process. The questions elicit information about behavioural aspects of engagement. In addition, each stakeholder in the project is requested to rate their participation and that of the other stakeholders using a 5-point visual analogue rating scale (**Figure 1**). Similar to the continuum

used by Rifkin, Muller & Bichmann (1988), a rating of one describes narrow participation while a rating of five describes wide participation.

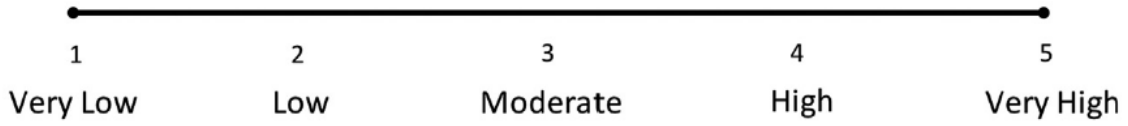

Figure 1 *5-point visual analogue rating scale for perceived level of participation. Adapted from Hendricks et al. (2018).*

2.2 Student involvement in health-related educational activities

In health education, students participate in a number of learning and research activities that include the public. These activities can have different educational outcomes relating to scope of and knowledge literacy, and production, management and communication of information (South African Qualifications Authority, 2012). The *intended* outcomes may allude to the beneficiary of the activities and the intended benefit itself; this raises the question of whether students solely benefit, or whether the students and the public benefit together. To identify the beneficiaries and the type of benefit, Furco (1996:3) suggests a continuum defining the provider and the recipient as well as the focus of the activities being undertaken (**Figure 2**). On the one end of this continuum there is the recipient as a beneficiary of a service being provided, on the other end there is the provider of a service and learning content as a focus. Activities can be positioned anywhere along this continuum. For example, activities that are more service-oriented will lie towards the recipient, while activities that are more learning-oriented will lie towards the provider of the service. Ideally, activities should be mutually beneficial where a service is provided and learning takes place.

Institutions of higher learning in South Africa centre their activities around three core functions,

Figure 2 *Continuum to determine placement of community-engaged activities by intended outcome and beneficiary. Adapted from Furco (1996:10).*

namely teaching and learning, research, and service (Thomson et al., 2011). During learning, students traditionally interact with one another and with an educator in the confines of a classroom (Khairnar, 2015). In addition, they may interact with the public for the purpose of

fulfilling academic requirements by providing a service; in health education this would be in the form of ward rounds or clinical rotations at a private or public health facility. In South Africa, this is mandatory in professional health sciences education and serves as a steppingstone to professional community service which commences immediately after graduation.

Activities pertaining to service are typically non-credit-bearing. For example, in South Africa, students would interact with the public during voluntary community initiatives which are optional and non-credit-bearing (Thomson et al., 2011). While the completion of professional community service is a requirement to register as a health professional with the Health Professions Council of South Africa (HPCSA) (Health Professions Council of South Africa, 2018), it is not affiliated with institutions of higher learning. Upon completion of professional community service and registration with the HPCSA, health professionals may work in either the public or private healthcare systems in South Africa.

Students may interact with the public to conduct research (Grand et al., 2015). In South Africa, postgraduate qualifications must include a minimum of 30 credits at honours level (National Qualifications Framework (NQF) level 8) or 60 credits at master's level (NQF level 9) dedicated to conducting research (Council on Higher Education, 2013). In the broader context of higher education, some educational activities will feature in one of the domains of learning, service or research, while others may feature in more than one of these domains simultaneously.

In the traditional method of teaching and learning, educators are the gatekeepers of knowledge. This is an old paradigm; a new approach is to actively engage students with course content and with each other (Ahlfeldt, Mehta & Sellnow, 2005), as methods of teaching that are engaged and interactive may be more satisfactory and effective than traditional methods (Brown, 2018, Moreno-Lopez et al., 2009). The assessment of participatory methods in health education by Gal et al. (2018) shows that these methods can enhance participation, motivation and interest in a subject matter, as well as cognitive aspects of learning.

2.2.1 Design thinking

Design thinking is a participatory method that can include community engagement (Roberts et al., 2016). It is a systematic process that is characterised by iterative phases and consistent involvement of the end-user to develop contextually relevant and effective solutions (Ferreira et al., 2015, Roberts et al., 2016). To develop successful solutions using this method, several elements are required, including a diverse and multidisciplinary group, collaboration, and multiple perspectives and backgrounds (McLaughlin et al., 2019). In the healthcare context, these solutions can be aimed at generating value for patients as users of health services. The

IDEO approach to design thinking consists of three phases, inspiration-ideation-implementation (Brown & Wyatt, 2010). The inspiration phase provides an opportunity to identify and understand the user, their context, and their challenges. Following this understanding, ideas are developed and tested in the ideation phase. Solutions become the "action plan" during the implementation phase. The Stanford d.school method has five phases, namely empathize-define-ideate-prototype-test (Doorley et al., 2018). Similar to the inspiration phase of the IDEO method, the empathize phase provides an opportunity to identify and understand the user, their context, and their challenges, while in the define phase a problem statement that will guide activities in subsequent phases is developed. Ideas are then generated in the ideate phase, and low fidelity prototypes developed in the prototype phase. These prototypes are tested in the testing phase.

Design thinking has been used as a pedagogical method in undergraduate and postgraduate courses in various subjects. These include industrial, interior, communication and digital media design programmes (Melles, Howard & Thompson-Whiteside, 2012, Orthel, 2015); education (Henriksen, Richardson & Mehta, 2017); and in health (Beaird, Geist & Lewis, 2018, Cahn et al., 2016, Carmel-Gilfilen & Portillo, 2016, Frankel, 2011, Jiang et al., 2017, Niccum et al., 2017, Trowbridge, Chen & Gregor, 2018, van de Grift & Kroeze, 2016, Yock, Brinton & Zenios, 2011). University courses that employ the design thinking method provide students with an opportunity to engage with one another and with the public to generate societal change.

2.2.2 Assessment of student engagement in learning activities

In the context of learning, assessment can be defined as a "systematic basis for making inferences about the learning and development of students…the process of defining, selecting, designing, collecting, analyzing, interpreting and using information to increase students' learning and development" (Erwin, 1991:15). To fully understand engagement, a holistic view that considers the process and the outcome of students engaging in learning activities is required (Kahu, 2013). A holistic view would integrate different aspects of engagement in a single assessment. Kahu (2013) proposes the use of in-depth qualitative methods in addition to quantitative measures to implement this holistic view.

To use assessments of student engagement to increase learning and development, several interrelated aspects of engagement must be considered. These include (Sharan, 2008):

1) Behavioural engagement, which describes a student's participation or involvement in academic activities;

2) Emotional engagement, which describes the attitude, interest and values which a student invests in learning activities; and
3) Cognitive engagement, which describes a student's motivation to learn, or self-regulation.

To assess student engagement at course level, several methods can be used, including surveys, questionnaires and observations. *The Survey of Student Engagement*, which is based on the National Survey of Student Engagement (NSSE), was developed to assess engagement in problem-based learning classes across varied levels of study in higher education (Ahlfeldt, Mehta & Sellnow, 2005). This questionnaire uses 14 questions from the NSSE to assess elements of physical contribution and cognitive engagement. In a health education context, it has been used to assess student engagement in a variety of physiology courses ranging between levels one to five of university education (Hopper, 2016). Other similar instruments include the *Classroom Survey of Student Engagement (CLASSE)* which assess elements of physical contribution, cognitive and emotional engagement (Ouimet & Smallwood, 2005) – this instrument has been used in a healthcare setting to assess nursing students' engagement in classroom activities (Reyes, 2007); and the *Student Course Engagement Questionnaire (SCEQ)* which assess elements of physical participation, emotional and cognitive engagement (Handelsman et al., 2005). These instruments provide a theoretical foundation to assess engagement, however they are not suitable to assess engagement in participatory projects such as in design thinking as they do not consider the phasic requirements which may have differing physical, emotional, and cognitive inputs.

2.2.3 The Burch Engagement Survey for Students

Burch et al. (2015) conceptualized student engagement based on Astin's (1984) theory of student involvement and on the work of Kahn (1990) which focused on engagement in the workplace. Kahn posits that engagement requires the investment of emotional, physical, and cognitive energy towards completion of tasks. Accordingly, Burch et al. (2015) modified the job engagement items proposed by Rich, Lepine & Crawford (2010) which were created to assess emotional, physical, and cognitive engagement in the workplace, to assess emotional, physical, and cognitive engagement in a class/course. This culminated with the creation of the Burch Engagement Survey for Students.

2.2.3.1 Physical engagement

Astin (1984) posits that the more involved a student is, the more physical and psychological energy they invest in academic tasks. Despite the definition including the concept of

psychological investment, which has since been defined as emotional (Sharan, 2008) investment, the author emphasizes the behavioural component when stating that “it is not so much what the individual thinks or feels,” instead it is the behaviour that exemplifies involvement.

Astin’s theory is consistent with the conceptualization of typologies of participatory research, and the associated assessment frameworks as they especially focus on participation as an independent factor describing involvement in community projects. This theory is also consistent with the assessment framework developed for design thinking (Hendricks et al., 2018), which emphasizes behavioural/physical engagement.

2.2.3.2 Emotional engagement

Rich, Lepine & Crawford (2010) argue that although Kahn (1990) did not propose that engagement is related to performance, engaged employees in the workplace invest emotional, physical, and cognitive energies. This is consistent with participatory health research which is valued as a way to improve user conditions (Goodman et al., 2017). Participatory health research commonly uses the term participation in an all-encompassing way; the associated assessment typologies solely assess physical input. To counter this limitation and acquire a more in-depth understanding of engagement, the Burch Engagement Survey for Students draws on the workplace emotional engagement items proposed by Rich, Lepine & Crawford (2010) to include emotional engagement items for students. By focusing on emotions, information pertaining to negative or positive emotions can be generated – this information could relate to the process of participation, as well as the prospective, retrospective, and social influences (Pekrun et al., 2002).

2.2.3.3 Cognitive engagement

The cognitive engagement items of the Burch Engagement Survey for Students are separated into cognitive engagement in the classroom and out of the classroom, and while community engagement may take place in a variety of settings, all of these settings are essentially part of ‘the classroom’. In addition, the Survey focuses solely on attention/focus for both in-classroom and out-of-classroom situations, rather than focusing on classroom activities, community engagement, or various other personal factors. Therefore, the Burch Engagement Survey for Students cognitive engagement component has limitations in assessing cognitive engagement in a community-engaged project.

2.2.4 Assessment of student engagement in participatory activities: design thinking

In recent years the application of the design thinking method as a pedagogy in higher education has increased. Several academic institutions have used it for learning and research practice – examples include the University of Amsterdam (van de Grift & Kroeze, 2016), University of Florida (Carmel-Gilfilen & Portillo, 2016), Shanghai University (Jiang et al., 2017), and the University of Cape Town (Conrad et al., 2019). Other than the University of California's Public Health Innovations course which administers an end-of-course student evaluation survey at the end of all the courses offered in the School of Public Health (Sandhu, Hosang & Madsen, 2015), no other assessments for design thinking at course level have been identified. While the survey may have several questions that allude to cognitive engagement, it does not assess student engagement with communities in the context of design thinking.

The phases of design thinking do however involve the emotional and physical aspects of engagement addressed in the Burch Engagement Survey for Students, while the cognitive engagement component of this survey is limited in its current form for assessing cognitive engagement in a community-engaged design thinking project. The design thinking phases (using the IDEO terminology) are described below with reference to elements of emotional and physical engagement and cognition:

Inspiration

To identify stakeholders and their challenges, and to understand the user and their environment, requires elements of physical participation i.e. observations and interviews, emotional investment and cognition to empathize with the user and to understand the factors that influence their behaviour. Cognition is further required to formulate a problem statement that will guide activities in subsequent phases.

Ideation

Similar to the define phase, ideation relies largely on elements of cognition. To create and test the functionality of (low fidelity) prototypes, and to empathize further with the user so as to improve knowledge of the user and their environment, elements of physical participation, emotional investment and cognition are required.

Implementation

This phase may involve the refinement of the problem statement, prototypes, and learning more about the user or their environment. To test prototypes will therefore require physical participation, emotional investment and cognition.

2.3 Summary

Various instruments and methods to have been developed to assess participation in health-related projects. For student engagement, the focus has mainly been on assessment of learning activities, rather than assessment of student engagement with communities. The instruments used to assess student engagement in learning are not suitable to assess engagement with communities in design thinking projects, because the phases of the design thinking process require different physical, emotional and cognitive inputs. Additionally, these instruments all use quantitative methods which do not fully explore the antecedents of student engagement. In particular, they do not account for the fluctuation in the required physical, emotional, and cognitive inputs that may occur when design thinking is applied as a pedagogical tool. Applying an instrument that does not account for these inputs would limit understanding of engagement.

Hendricks et al. (2018) propose an assessment framework to assess participation in design thinking. The instrument is not suitable to assess *student engagement* as it focuses solely on behavioural or physical participation, neglecting the emotional and cognitive aspects of engagement. Additionally, this instrument is designed to assess power-sharing between stakeholders of different categories and does not focus on students in a learning context. Therefore, using this framework to assess student engagement at course level when design thinking is applied as a pedagogical method, would require adjustments for emotional engagement and cognitive engagement to be addressed.

The Burch Engagement Survey for Students (Burch et al., 2015) provides a means of addressing physical, emotional and cognitive engagement, although the cognitive engagement component is not suitable for assessing cognitive engagement in a community-engaged project. The Survey focuses solely on attention/focus as cognitive engagement for both in-classroom and out-of-classroom situations. Therefore, the cognitive engagement component has limited utility in assessing cognitive engagement in a community-engaged project.

3 Methods

The aim of this study was to develop a framework to holistically assess student engagement, in the domains of physical, emotional, and cognitive engagement, in a course that uses a design thinking approach for health innovation. In using design thinking principles, the course is participatory as it involves engagement with external stakeholders/end-users and consists of iterative phases (Ferreira et al., 2015, Roberts et al., 2016).

3.1 Research design

The following data collection methods were used (1) a questionnaire containing open and closed questions was developed and implemented based on scientific literature; (2) written reflective reports submitted in partial fulfilment of the requirements for the Health Innovation and Design course were examined; and (3) a focus group was conducted. Together, these methods were used to triangulate information towards validation of data items (Olsen, 2004:103), as shown in **Figure 3**. Triangulation is the use of multiple sources of data about a single phenomenon to provide a comprehensive understanding of the phenomenon under examination (Carter et al., 2014). It can be used to cross-reference aspects of a phenomenon that may need to change or improve (Ouimet et al., 2004). In addition, the resulting questionnaire was validated by design thinking practitioners.

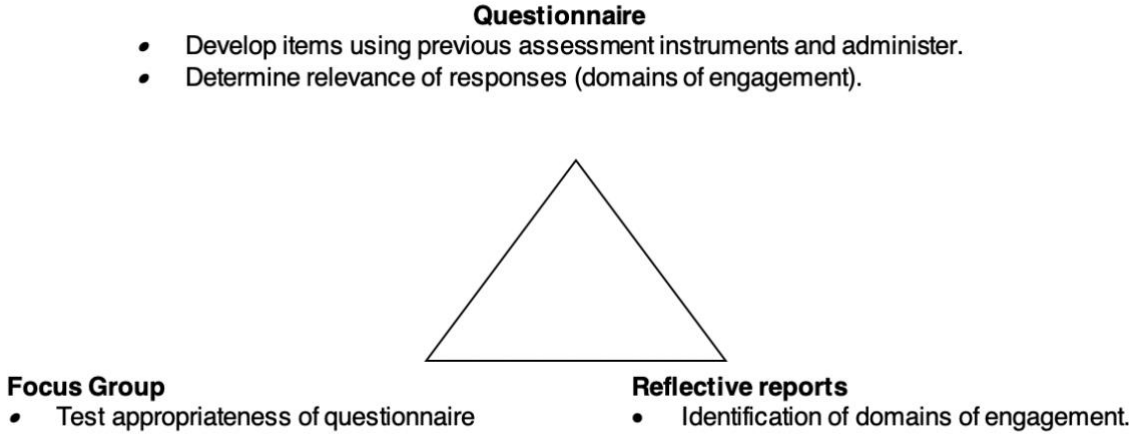

Figure 3 *Data collection tools.*

3.1.1 Study participants

A purposive sample of students who were registered for the Health Innovation & Design (HUB5031F) course in 2019 was invited to participate in this study. The course forms part of

the requirements for the degree of Master of Philosophy in Health Innovation and the Master of Science in Biomedical Engineering.

3.1.2 Design thinking challenge

The design thinking challenge for the course was formulated with the Health Manager at a residence for elderly citizens in Cape Town. The group of 16 students was separated into three groups, with each addressing the challenge in its own way. The challenge ran for two months; during this period, students attended lectures and completed activities in accordance with the design thinking methodology. These activities included engagement with various stakeholders outside the university community.

3.1.3 Ethical considerations

The Human Research Ethics Council of the Faculty of Health Sciences, University of Cape Town approved this study (HREC REF: 247/2019). In addition, the Department of Student Affairs, University of Cape Town, approved access to students for the research project. Participants were provided with information on (i.e. study purpose, participation and right to withdraw, confidentiality, and risks and benefits of participation) and procedures of the study and provided electronic informed consent prior to participating.

3.1.4 Overview of study

The guidelines for questionnaire development by Gehlbach, Artino & Durning (2010) were applied. This seven-step design process was initially proposed in response to limited guidance for the development of surveys. The guidelines propose the following steps for questionnaire development: (1) conducting a literature review of relevant research, (2) conducting interviews and focus groups, (3) combining steps one and two, (4) development of questionnaire items, (5) conducting expert validation, (6) conducting cognitive interviews, (7) and conducting pilot testing. While the current study complies with these steps in principle, there are several key differences which are illustrated in **Figure 4**.

These differences are related to the iterative nature of design thinking, in which conducting interviews at one point could be ‘too early’ as that particular activity might be reiterated and as such relevant information could be missed. Therefore, instead of conducting interviews directly after a literature review, the current study collated items for a questionnaire and administered the questionnaire (i.e. conduct pilot testing), following which the written reports, which were submitted by the students in partial fulfilment of the requirements for the Health Innovation and Design course, were analysed to supplement and triangulate data collected

from the questionnaire responses. Once this process was completed, a focus group was conducted with the questionnaire respondents. In addition, practitioner validation was conducted with the course lecturer and facilitators. By triangulating the data gathered using these tools, a final questionnaire could be composed with validation from design thinking practitioners who represent the experts required for questionnaire validation in the Gehlbach, Artino & Durning (2010) guidelines.

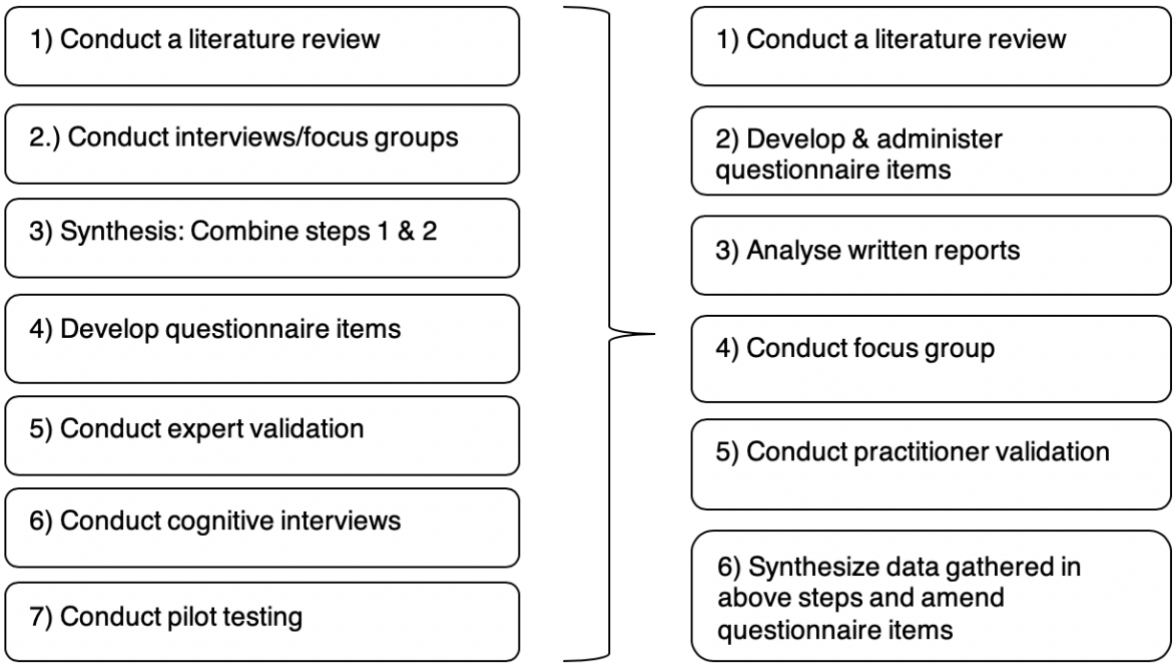

Figure 4 *Questionnaire development guide for medical education research. Adapted from Gehlbach, Artino & Durning (2010). The process diagram on the left is the original questionnaire development guide, while the process diagram on the right was followed in this study.*

3.2 Questionnaire design and implementation

Several design thinking principles were considered when designing the questionnaire; these are:

- The phasic and participatory nature of design thinking.
- Multiple settings in which project activities are conducted.
- The involvement of various stakeholders.

In addition to the principles above, the questionnaire items were aligned with:

1. The objective of designing a questionnaire to assess *student engagement* thus it incorporates elements of physical, emotional, and cognitive engagement.
2. The stakeholder participation assessment framework for design thinking proposed by Hendricks et al. (2018) – this framework considers the phasic nature of design thinking

in accordance with the IDEO method (Brown & Wyatt, 2010). The framework consists of a rating scale (with descriptors) to assess participation amongst stakeholders.

3. Requirements of the Health Innovation & Design course, including a written reflective report of the students' experiences throughout the design thinking project. Reflective journals provide insights into the writer's reasoning, perspective and emotional response to an event as it evolved (Jasper, 2005). Additionally, they provide insights into the writer's "values, attitudes, beliefs and behaviour" and what may have influenced the events that ensued (Phelps, 2005). Therefore, the written reflective reports that the students submitted in partial fulfilment of the requirements for the course were used as a source of evidence to aid an understanding of engagement in the project.

3.2.1 Questionnaire items

Questionnaire items are grouped according to the IDEO method (Brown & Wyatt, 2010) of design thinking. The questionnaire items included in the initial questionnaire are provided in **Table 1**, along with a description of the literature informing each item is provided with the respective item/s.

Table 1 *Initial questionnaire items.*

	Domain of engagement	Question	Motivation	Type of answer
Inspiration Phase				
1	Physical engagement	How were the project stakeholders identified?	These items were formulated to coincide with the interview guide questions proposed by Hendricks et al. (2018) for the inspiration phase of the design thinking project.	Narrative
2	Physical engagement	How were stakeholder needs/challenges identified?		
3	Physical engagement	What was your role during this phase of the project?		
4	Emotional engagement	I enjoyed the participatory methods of data collection during the inspiration phase.	Enjoyment in the context of learning is positively correlated with motivation to learn and subsequent academic efforts (Pekrun et al., 2002). Pekrun (2006) states that when academic activities and related material are valued, and the academic activities are perceived to be controllable, they promote enjoyment. Therefore, assessing enjoyment on a Likert-scale provides an opportunity to descriptively link this item to outcome emotions such as pride or satisfaction on the positive end, or disappointment or shame on the negative end of a spectrum of emotions that are directly linked to learning activities or outcomes, these are known as achievement emotions (Pekrun, 2006).	Likert scale
5	Cognitive engagement	Do you think that the interactive methods of data collection during the inspiration phase enhanced your ability to successfully identity relevant stakeholders?	Hake (1998) compared the interactive-engagement and traditional methods of teaching in physics and found that the engaged method increase effectiveness and problem-solving ability. Design thinking uses similar principles i.e. interactive engagement for problem solving – it is therefore expected that participants will answer yes to the question.	Closed (yes/no)
6	Cognitive engagement	Do you think that the interactive methods of data collection during the inspiration phase enhanced your ability to successfully identity relevant stakeholder challenges?		
7	Cognitive engagement	Please provide a reason for your answer in the previous two questions.		Narrative
8	Cognitive engagement	Prior to meeting the community stakeholders, my team planned how to collect the data to enable us to collect as much information as possible.	This item is adapted from the Cognitive Engagement – Short form (CE-S) (Smiley & Anderson, 2011). The authors describe this item as a “measure (of) meaningful cognitive engagement” – in the context of design thinking for pedagogy, this item is particularly useful because it assesses the students’ plan to become fully immersed in the community stakeholders’ environment which can enhance the data collection process thus enriching the information that is collected.	Likert scale
Ideation Phase				
9	Physical engagement	Please describe the role you played during the ideation phase of the project.	This item amalgamates the interview guide questions proposed by Hendricks et al. (2018) for physical engagement.	Narrative

10	Emotional engagement	I was positive (i.e. enthusiastic, excited, energetic, interested) about the activities that we undertook during the ideation phase of the project.	To measure emotional engagement, Burch et al. (2015) use several emotions which Pekrun et al. (2002) describe as positive emotions. Therefore, this item combines the emotional engagement items proposed by Burch et al. (2015) into one item by asking participants to rate positivity during a particular phase. Since the Ideation phase is one in which a physical low fidelity prototype/s is created following an understanding of challenges within their context and ideating and planning a way towards solving the challenges, this particular question is asked in this phase.	Likert scale
11	Cognitive engagement	Did you read any literature to help you with generating ideas during the ideation phase?	According to Pekrun et al. (2002) enjoyment is positively correlated to interest, total motivation to learn, and academic effort. It is therefore expected that participants who enjoyed participating in the activities during the inspiration phase, and those who were positive about the activities during the ideation phase, would answer *yes* to questions 11 and 13. A student who is not interested or motivated to learn might be unlikely to read additional material to better enhance their cognitive engagement with the material and course activities.	Closed (yes/no)
12	Cognitive engagement	Please provide a reason for your answer in the previous question.		Narrative
13	Cognitive engagement	Did you read any literature to help you to create prototypes during the ideation phase?		Closed (yes/no)
14	Cognitive engagement	Please provide a reason for your answer in the previous question.		Narrative
15	Cognitive engagement	When my team was generating ideas, I stopped to ask myself whether or not I/we understood the information that we collected in the inspiration phase.	This item is adapted from the work of Greene & Miller (1996) on influences on achievement. In the context of design thinking for pedagogy, this item provides information about the students' cognitive approach to solving the identified challenges i.e. were the students cognitively engaged in the process or not.	Closed (yes/no)
Implementation Phase				
16	Physical engagement	What role did you play during the implementation phase of the project?	This item amalgamates the interview guide questions proposed by Hendricks et al. (2018) for physical engagement.	Narrative
17	Emotional engagement	I am proud of our final product of the project.	This item provided respondents with an opportunity to describe their reasons why they thought that the design thinking method was useful, or not, for them in developing solutions.	Likert scale
18	Cognitive engagement	Please provide a reason for your answer to the previous question.	This item provided respondents with an opportunity to describe their reasons pride, or lack of pride, in their final solution.	Narrative
19	Cognitive engagement	I think that the participatory nature of design thinking was useful for my team to generate, plan, and produce a novel solution.	N/A	Closed (yes/no)
20	Cognitive engagement	Please provide a reason for your answer to the previous question.	This item provided respondents with an opportunity to describe their reasons why they thought that the design thinking method was useful, or not, for them in developing solutions.	Narrative

In addition to the above items, a rating scale was used to assess perceived level of participation. Participants rated their own level of participation, and that of their colleagues, after each phase of the project. Instructions were as provided below:

Please complete the scale to rate your own participation throughout the [ ] phase
1 – Very Low (I did not participate in any decision-making)
2 – Low (I participated in few decision-making activities)
3 – Moderate (Decision-making was partly shared; group leader had the final say)
4 – High (I participated in most of the decision-making activities)
5 – Very High (I participated in all of the decision-making activities)

Please complete this scale to rate the participation of your group members throughout the [ ] phase.
1 – Very Low (My group members did not participate in any decision-making)
2 – Low (My group members participated in few decision-making activities)
3 – Moderate (Decision-making power was partly shared; group leader had the final say)
4 – High (My group members participated in most of the decision-making activities)
5 – Very High (We all participated in all of the decision-making activities)

3.2.2 Questionnaire implementation

The initial questionnaire (**Table 1**) was administered to participants of the course. The questionnaire was sent to the participants by electronic mail for completion. It included information about the study and electronic consent. The questionnaire was administered once all the phases of the design thinking project were completed.

3.2.3 Questionnaire analysis

Of interest in the questionnaire was whether or not the participants' responses matched/provided the information that was sought by the questionnaire item. For example, questions based on the assessment framework for design thinking proposed by Hendricks et al. (2018) are on physical engagement, so the responses should ideally provide information relating to physical engagement. In addition, the consistency in the answers provided by all respondents was examined to understand the nuances of participation. To assess consistency, a narrative response was sought following a rated answer to provide information beyond the rated response (i.e. the *how* and *why*) and may be useful for identifying predictors, enablers, and/or inhibitors of participation.

To identify the relevant information that relates to the intended aspect of engagement, content analysis was used. Content analysis is “the study of recorded human communications” (Babbie, 2014:341), including written communication. Of interest was the presence of words/terms or phrases that related to any of the aspects of engagement that were being tested. Difficulties that were identified in the questionnaire responses (i.e. any misunderstandings; answers that related to an aspect of engagement that was *not* being tested in any of the items) were noted for discussion.

Closed question items and the rating scales were analysed and/or graphed using GraphPad Prism 8 (GraphPad Software Inc, San Diego, CA, USA). The Likert scale anchors were: very low, low, moderate, high, and very high. These are in accordance with the visual analogue rating scale for perceived level of participation (**Figure 1**) proposed by Hendricks et al. (2018). Descriptive statistics were used to analyse the data.

3.3 Written reflective reports

In addition to the literature which informed the questionnaire items, the students’ written reflective reports were used to identify aspects of physical, emotional, and cognitive engagement that may have been missed in the questionnaire, as a means to identify gaps in the questionnaire.

The written reflective reports for the Health Innovation & Design course are intended to be a comprehensive evaluation of the students’ insights gained regarding the design challenge, the design process and the final solution. The report consists of a reflective component on the practical learning experience in the course and therefore may contain information relating to all aspects of engagement.

Similar to the analysis of the narrative questionnaire items, content analysis was applied to the written reports. Aspects of engagement – physical, emotional, cognitive – were identified and coded in the text. Coding is used to process raw data, according to a conceptual framework, into a standard format (Babbie, 2014:346). Of interest in the written reports was the presence of explicit evidence relating to any of the aspects of engagement. In addition, any relevant information that was evident in the written reports but had not been considered for the questionnaire was noted as a recommendation for the final iteration of the questionnaire. Information from the written reports that needed clarification was noted.

3.4 Focus group

At the beginning of the focus group, each participant was given the questionnaire that had previously been circulated for completion. This was done for ease of reference during the discussion.

Respondents' understanding of the nature of the questionnaire items and the ease with which they could answer the items was tested in the focus group (Babbie, 2014:273, Beatty & Willis, 2007). Several aspects of the questionnaire were discussed, including the questionnaire headings and/or lack of instructions, the timing of administration of the questionnaire, specificity of the terms used in the items, separation of questionnaire sections according to the phase of a design thinking project, participants' conceptualisation of the questionnaire items, and their perception of the relevance and clarity of the items.

The focus group further provided participants with an opportunity to elaborate and explain how they approached certain items and whether they faced any difficulties answering the items (Beatty & Willis, 2007). The focus group guide questions (**Table 2**) provided a platform to elicit themes and subthemes in the discussion. Difficulties noted in the questionnaire responses and unclear information from the written reports were raised for discussion.

Table 2 *Focus group guide questions*

1.	What is your overall impression on the relevance of the questions in the [ ] phase ?
2.	Do you think the questions elicit enough information about your experiences during the course?
3.	Which questions do you think can be removed, and why?
4.	What do you think of the participation rating scales?
5.	There were times when ideas or prototypes were well received/not well received. How did this make you feel?
6.	How do you think emotional fluctuations affected your participation throughout the phases of the project?
7.	Some groups consulted healthcare workers or external organisations like Community Health Intervention Programmes (CHIPs) during the course. What are your thoughts on this? *This question relates to potential interest (cognitive) to interact with additional stakeholders (physical).*

The focus group discussion was audio recorded, with the participants' consent. The focus group discussion was approximately one hour in duration.

Data from the focus group were transcribed and analysed to identify themes in the participants' responses and discussion. Thematic analysis is a process of identifying and reporting themes that appear in a dataset that is transcribed; a theme is a patterned response in the dataset that relates to the research question/s (Braun & Clarke, 2006), and may be identified as occurrences of difficulties or enablers of participation at an individual or group level. Such

enablers can provide the questionnaire administrator to identify avenues to enhance participation in the group.

3.5 Practitioner validation

Based on the analysis of the questionnaire responses, the written reports and the focus group, the questionnaire items were revised to better assess student engagement during design thinking for health innovation.

The revised questionnaire was discussed with the Health Innovation & Design course lecturer and facilitators (as design thinking practitioners) for further validation.

To determine practitioners' expert views on the questionnaire and the extent to which the items measure all the aspects of engagement, a separate questionnaire (**Table 3**) was developed and sent by electronic mail for completion. In this questionnaire, the practitioners were requested to rate their level of agreement that the collection of items in each section/phase fully encompass the aspects of engagement that the questionnaire aims to assess. Similarly to Visser et al. (2019) in their questionnaire development and preliminary evaluation, a Likert scale was used. To collect explanatory data in support of the practitioners' views, each rated item was followed by a narrative item in which practitioners could suggest and/or motivate any further revisions.

A courtesy note for reference, defining the aspects of engagement according to Sharan (2008), was included in the instructions section of the questionnaire.

Table 3 *Design thinking practitioner validation questionnaire items*

Item #	Question item	Type
Inspiration phase *All the questionnaire items in this section relate only to the inspiration phase of a project.*		
1	The physical engagement items in this phase are able to elicit sufficient information about the participatory activities undertaken.	Likert scale
2	Please explain your answer to the previous question item – you may provide feedback on any of the respective questionnaire items.	Narrative
3	The emotional engagement items in this phase are able to elicit sufficient information about the participatory activities undertaken.	Likert scale
4	Please explain your answer to the previous question item – you may provide feedback on any of the respective questionnaire items.	Narrative
5	The cognitive engagement items in this phase are able to elicit sufficient information about the participatory activities undertaken.	Likert scale
6	Please explain your answer to the previous question item – you may provide feedback on any of the respective questionnaire items.	Narrative
Ideation phase *All the questionnaire items in this section relate only to the ideation phase of a project.*		
7	The physical engagement items in this phase are able to elicit sufficient information about the participatory activities undertaken.	Likert scale
8	Please explain your answer to the previous question item – you may provide feedback on any of the respective questionnaire items.	Narrative
9	The emotional engagement items in this phase are able to elicit sufficient information about the participatory activities undertaken.	Likert scale
10	Please explain your answer to the previous question item – you may provide feedback on any of the respective questionnaire items.	Narrative
11	The cognitive engagement items in this phase are able to elicit sufficient information about the participatory activities undertaken.	Likert scale
12	Please explain your answer to the previous question item – you may provide feedback on any of the respective questionnaire items.	Narrative
Implementation phase *All the questionnaire items in this section relate only to the implementation phase of a project.*		
13	The physical engagement items in this phase are able to elicit sufficient information about the participatory activities undertaken.	Likert scale
14	Please explain your answer to the previous question item – you may provide feedback on any of the respective questionnaire items.	Narrative
15	The emotional engagement items in this phase are able to elicit sufficient information about the participatory activities undertaken.	Likert scale
16	Please explain your answer to the previous question item – you may provide feedback on any of the respective questionnaire items.	Narrative
17	The cognitive engagement items in this phase are able to elicit sufficient information about the participatory activities undertaken.	Likert scale
18	Please explain your answer to the previous question item – you may provide feedback on any of the respective questionnaire items.	Narrative

While this study did not employ pure quantitative measures for validation, the principle of fewer than five “experts” having to be in agreement (Lynn, 1986) was applied for methodological rigor. None of the design thinking practitioners who participated in this part of the study were involved in the design and development of the initial questionnaire items.

Similarly to Visser et al. (2019), ratings of 3 to 5 were considered as valid, in which case an item would remain in the questionnaire. In the case of a low rating i.e. 1 and 2, a decision was

made by the research team to keep, remove, or rephrase the item. Such a decision considered the narrative explanation provided by the practitioner/s.

4 Results

Sixteen invitations to participate in the study were sent to students registered for the Health Innovation and Design course; six responses were received. Therefore, six participants completed the questionnaire and attended the focus group. Five written reports were analysed, not six, as one of the participants in the course was not a formally registered student therefore the participant was not obliged to submit a written report.

4.1 Questionnaire Reponses

Questionnaire responses are presented by phase of the design thinking process. The items are grouped according to the IDEO design thinking method, and in the original order in which they appear in the initial questionnaire. The rating scales appear last and are presented in a nested graphical format. All the questionnaire items are presented. Feedback from the focus group is reported on to clarify responses and justify revisions to the questionnaire.

To illustrate the difficulties that were experienced by the participants in completing the questionnaire, relevant quotations from the focus group have been integrated into this section.

4.1.1 Inspiration phase

How were the project stakeholders identified? (Narrative item)

Of the six responses, only three provided an answer that was unequivocally behavioural in nature and therefore related to physical engagement. The other responses did not provide an answer detailing the manner in which stakeholders were identified; reasons given in the focus group were confusion and broadness of the question which incited “lots of speculation” about what a suitable answer would be.

How were stakeholder needs/challenges identified? (Narrative item)

All six responses to this item were behavioural – related to physical engagement. All responses provided specific answers, mainly related to stakeholder engagement through interviews. This suggested that the respondents had no difficulties understanding the question, nor providing an appropriate answer. However, there was uncertainty about the boundaries of the term stakeholder in the question; does it refer to the user, “main stakeholder/s”, or course lecturer and facilitators:

> *“Are you referring to stakeholders as in …or stakeholders as in everyone involved within the solution that we created?”* (Participant 2)

A participant suggested a solution to clarify the question:

> *"You could put brackets and just explain a bit what you want…like [the] user or management if you want it to be that broad then it would clarify it"* (Participant 1)

While this *solution* might provide clarity, it could potentially take away from respondents their autonomy in deciding whom they perceive as a stakeholder and person with relevant information to help in developing a novel solution.

What was your role during this phase of the project? (Narrative item)

Three of the six responses were behavioural in nature, while the rest were either ambiguous or related to cognitive engagement, instead of physical engagement which was the target aspect of engagement being tested. A reason cited for the difficulty was the ambiguity of the word "role" in the questionnaire item:

> *"Are you referring to like contribution or are you referring to role within what is engagement or what is expected of me or like which part of that phase was I responsible for?"* (Participant 2)

> *"I found it hard to answer because we never thought of it as a role."* (Participant 4)

An example alternative to the ambiguity of the word *role* was to rephrase the question to:

> *"…how do you feel you contributed in this phase?"* (Participant 4)

Given the link between questionnaire items seven and thirteen on the original questionnaire, it was said that:

> *"I think it is easier to answer [question] thirteen…I feel like this is more beneficial because here you can quantify it better"* (Participant 2)

A revised item was included in the questionnaire in response to the difficulty identified: *What was your contribution during this phase of the project?* This revision was applied to all three occurrences of this item, i.e. for each phase.

I enjoyed the participatory methods of data collection during the inspiration phase (Likert scale item)

During the Inspiration phase, participants mostly enjoyed the participatory methods of the data collection i.e. interaction with the project stakeholders, with five of six respondents rating 4 or 5 on the rating of level of agreement i.e. high levels of agreement (**Figure 5**).

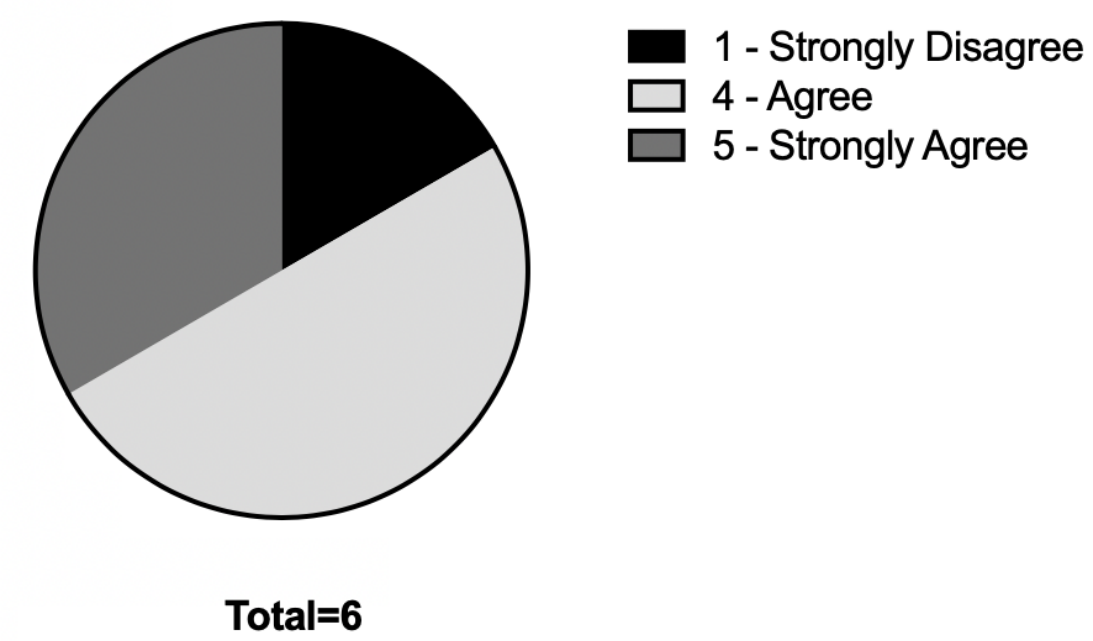

Figure 5 *Responses to the questionnaire item, "I enjoyed the participatory methods of data collection during the inspiration phase."*

There were several concerns with wording and broadness of this item. Participants were unsure of the meaning of "participatory methods" and "data collection." In addition, they were unsure of the context which the question referred to:

> *"I think if you wanted a more particular answer, let's say about the interviews [you could say] I enjoyed the participatory methods of like in class or during group work or during teamwork…is it in the environment of when we as a group worked together or is it in the environment when we actually go out and retrieve information or when we work on that specific information?"* (Participant 2)

Burch et al. (2015) propose that students can be cognitively engaged "in class" and "out of class". Since students interact with one another in class and with community members out of class, it is plausible that they may be emotionally engaged in class and out of class – it is therefore crucial that both in contexts are assessed. As such, a revised item (split into two questions) was included in the questionnaire:

1. *I enjoyed the participatory techniques of collecting information during class time in the inspiration phase.*

2. *I enjoyed the participatory techniques of collecting information when interacting with stakeholders during the inspiration phase.* Both items will apply the same 5-point rating scale used in the original questionnaire item.

Do you think that the interactive methods of data collection during the inspiration phase enhanced your ability to successfully identity relevant stakeholders? (Closed item)
All the respondents thought that interaction with the stakeholders enabled them to successfully identify the relevant stakeholders (**Figure 6**).

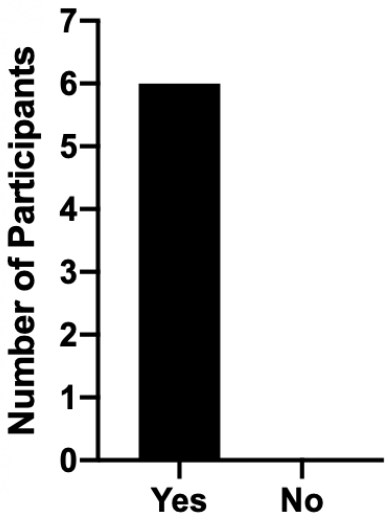

Figure 6 *Responses to the questionnaire item, "Do you think that the interactive methods of data collection during the inspiration phase enhanced your ability to successfully identity relevant stakeholders?"*

Similar to the questionnaire item above, the term "data collection" in this item required a change, to *collecting information.* A revised item: *Do you think that the interactive methods of collecting information during the inspiration phase enhanced your ability to successfully identity all the relevant stakeholders?*

Do you think that the interactive methods of data collection during the inspiration phase enhanced your ability to successfully identity relevant stakeholder challenges? (Closed item)
All the respondents thought that interaction with the stakeholders enabled them to successfully identify relevant stakeholder challenges (**Figure 7**).

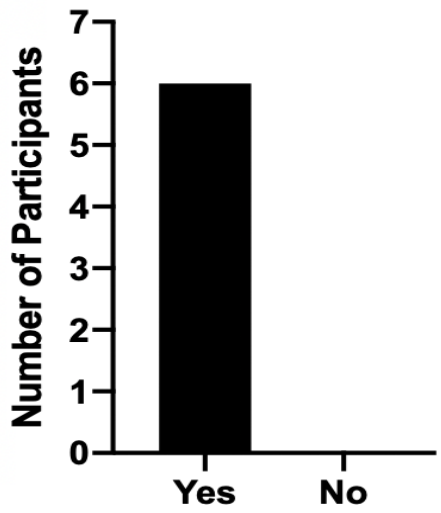

Figure 7 *Responses to the questionnaire item, "Do you think that the interactive methods of data collection during the inspiration phase enhanced your ability to successfully identity relevant stakeholder challenges?"*

Similar to the questionnaire item above, the term "data collection" in this item required a change, to *collecting information.* A revised item: *Do you think that the interactive methods of collecting information during the inspiration phase enhanced your ability to successfully identity relevant stakeholder challenges?*

Please provide a reason for your answer in the previous question (to: Do you think that the interactive methods of data collection during the inspiration phase enhanced your ability to successfully identity relevant stakeholder challenges?) (Narrative item)

A primary belief that is consistent throughout the responses to this item is that interaction with the user provides an opportunity to confirm relevant information about the user. In addition, teamwork for user-centred approaches was cited as helpful to identify stakeholder challenges. While there were no difficulties in answering this question, it was stated that, with regard to the timing of asking this question:

> *"Sooner will always be the most ideal scenario."* (Participant 4)

By asking this questionnaire item soon after interacting with stakeholders (this is consistent with the methods employed by Furze et al. (2011) where students completed a reflective questionnaire on their experiences participating in community engagement activities within 24-hours after the session), participants would be more likely to recall information with greater

detail and ease. However, the iterative nature of design thinking makes this difficult to coordinate. In addition:

> *"For one particular day I might have not, like, contributed at all…by having to comment on the entire inspiration phase might be difficult because there are various contributing dates [on which we work on this phase] which will change based on human stuff."* (Participant 2)

Prior to meeting the community stakeholders, my team planned how to collect the data to enable us to collect as much information as possible (Likert scale item)

During the inspiration phase participants were mostly prepared for stakeholder engagement and data collection, as five of six respondents rated 4 or 5 on the rating of level of agreement i.e. high rating (**Figure 8**).

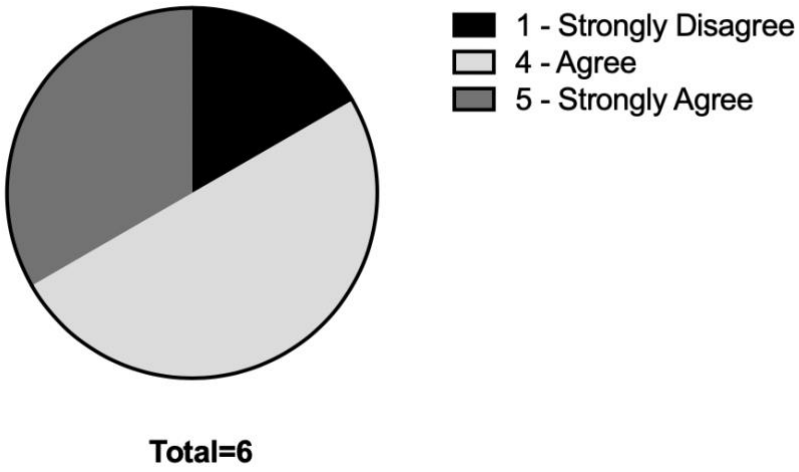

Figure 8 *Responses to the questionnaire item, "Prior to meeting the community stakeholders, my team planned how to collect the data to enable us to collect as much information as possible."*

4.1.2 Ideation phase

Please describe the role you played during the ideation phase of the project (Narrative item)

Four of the six responses to this item provided an answer that relates to cognitive engagement, such as brainstorming, instead of a physical engagement, which was the intended aspect of engagement targeted by the question. The other responses were ambiguous and unrelated to any of the aspects of engagement. A reason given was the ambiguity of the word *role* in the questionnaire item; participants did not think of their involvement in the project as a role.

A revised item was included in the questionnaire: *Please describe your contribution during the ideation phase of the project.*

I was positive (i.e. enthusiastic, excited, energetic, interested) about the activities that we undertook during the ideation phase of the project (Likert scale)

During the Ideation phase, participants were mostly positive about the activities they had undertaken, as five of the six respondents rated 4 or 5 i.e. high level of agreement (**Figure 9**). Participants had no difficulties answering this item, because:

> *"It was quite a specific question."* (Participant 5)

A reason for this was that:

> *"I think especially that you have put in brackets some of the [emotions]."* (Participant 1)

The appreciation of the use of brackets to expand on positivity in this item is consistent with the request for the use of brackets for clarity in rating scales.

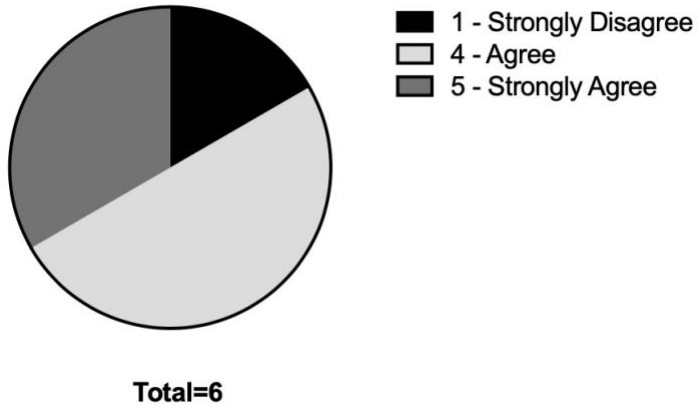

Figure 9 *Responses to the questionnaire item, "I was positive (i.e. enthusiastic, excited, energetic, interested) about the activities that we undertook during the ideation phase of the project."*

Did you read any literature to help you with generating ideas during the ideation phase? (Closed item)

Only one of six respondents read related literature to help with generating ideas (**Figure 10**). Although the course does not formally and explicitly require students to read literature to help with generating ideas, the responses raise the question of whether or not the students were motivated to read related literature beyond the course requirements.

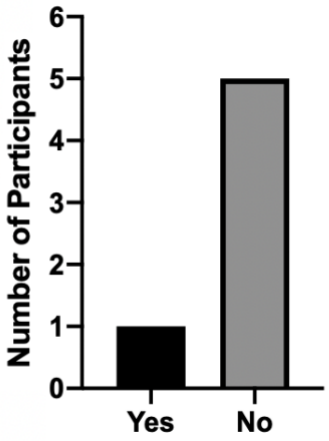

Figure 10 *Responses to the questionnaire item, "Did you read any literature to help you with generating ideas during the ideation phase?"*

There was some confusion about the specific meaning of the word "literature" in this item: five of six participants said they did not read any literature, however:

> *"We were given the design thinking tools [to read]"* (Participant 5)

It appears the readings on the design thinking toolkits were understood differently to other scientific literature which may have been related to the project topic. Therefore, the item needs to be more explicit.

A revised item was included in the questionnaire: *Did you read any material on design thinking or literature related to the project topic to help you with generating ideas during the ideation phase?* This change was applied to the closed item about literature to help with creating prototypes below.

Please provide a reason for your answer in the previous question (to: Did you read any literature to help you with generating ideas during the ideation phase?) (Narrative item)
Five of six respondents thought that reading literature was not necessary, or that teamwork was sufficient. One respondent suggested that while they initially thought it was not necessary to read literature, they believe it would have been beneficial – this reasoning is the same as that provided by the respondent who did read literature. None of the respondents mentioned that there was no instruction to read literature during the Ideation phase in their response.

Did you read any literature to help you with creating prototypes during the ideation phase? (Closed item)

Only one of six respondents read related literature to help with creating prototypes (**Figure 11**). The course does not formally and explicitly require students to read literature to help with generating prototypes.

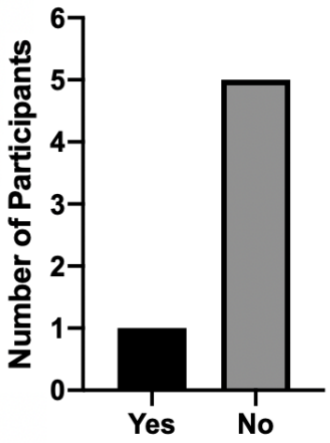

Figure 11 *Responses to the questionnaire item, "Did you read any literature to help you with creating prototypes during the ideation phase?"*

Please provide a reason for your answer in the previous question (to: Did you read any literature to help you with creating prototypes during the ideation phase?) (Narrative item)
The reasons provided for not reviewing literature for prototyping were similar to those for ideation. One response cited "prior knowledge", however the response does not clarify the specific knowledge area or subject/s. The one respondent who reviewed related literature explained that the group ("we") reviewed literature to confirm whether their ideas were relevant or not.

When my team was generating ideas, I stopped to ask myself whether or not I/we understood the information that we collected in the inspiration phase (Closed item)
Respondents were cognisant of the importance of the accuracy of the information collected during the Inspiration phase, as all six respondents said that they did stop to ask themselves whether they understood the information that they had collected (**Figure 12**).

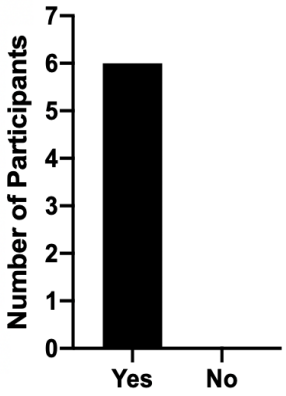

Figure 12 *Responses to the questionnaire item, "When my team was generating ideas, I stopped to ask myself whether or not I/we understood the information that we collected in the inspiration phase."*

4.1.3 Implementation phase

What role did you play during the implementation phase of the project? (Narrative item)

Five of six responses to this item were unequivocally behavioural in nature, suggesting that the question addressed the target aspect of engagement. This is in stark contrast to the same question for the Inspiration and Ideation phases, where only three and four respondents respectively provided a response that was behavioural. The one other response was ambiguous and did not relate to any of the aspects of engagement.

For consistency, the word role in this item was also replaced with contribution.

A revised item was included in the questionnaire:

What was your contribution during the implementation phase of the project?

I was proud of our final product of the project (Likert scale)

By the end of the design thinking project, participants were mostly proud of the solution/s that they had co-created with the stakeholders, as five of six respondents rated 4 or 5 on the rating of level of agreement i.e. high level of agreement (**Figure 13**).

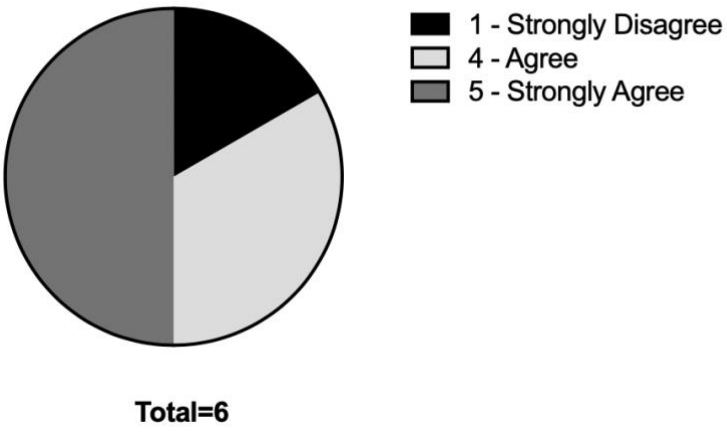

Figure 13 *Responses to the questionnaire item, "I was proud of our final product of the project."*

Please provide a reason for your answer to the previous question (to: I am proud of our final product of the project.).

All responses cited positive feedback and/or that their solution was well received, as a reason for this emotional response.

I think that the participatory nature of design thinking was useful for my team to produce a novel solution (Closed item)

Participants thought that the interactive nature of design thinking was useful in aiding them to produce a novel solution (**Figure 14**).

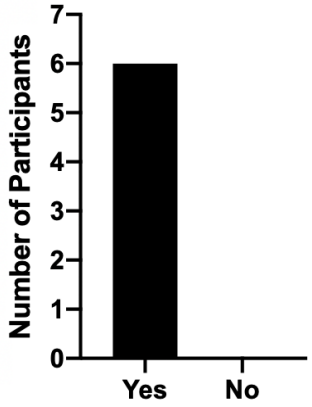

Figure 14 *Responses to the questionnaire item, "I think that the participatory nature of design thinking was useful for my team to produce a novel solution."*

Although there were no difficulties understanding or providing an answer for this item, participants agreed that "interactive" is a synonym for "participatory" that could also be used.

A revised item was included in the questionnaire:
I think that the participatory/interactive nature of design thinking was useful for my team to generate, plan, and produce a novel solution.

Please provide a reason for your answer to the previous question (to: I think that the participatory nature of design thinking was useful for my team to generate, plan, and produce a novel solution.).
All respondents thought that different perspectives and skills (academic background) were vital. In addition, continuous refinement of the solution was cited as a reason.

4.1.4 Participation rating scales

Participation rating scales are presented in a nested graphical format so that all data points (each respondent's rating) is visible; data are presented with different icons denoting a different phase of the project according to the IDEO design thinking method.

The participants' overall perceived levels of participation throughout the phases of the project, according to the rating scale descriptors proposed by Hendricks et al. (2018), is described as high (**Figure 15**).

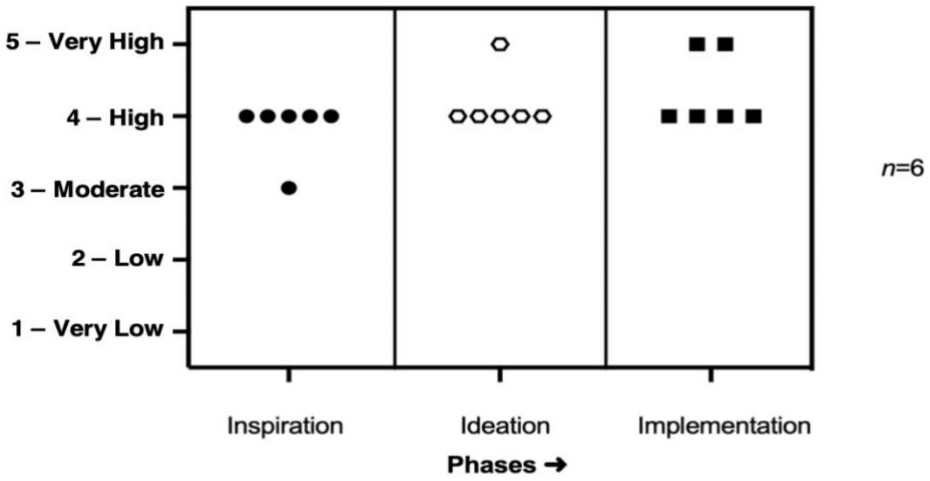

Figure 15 *Self rated participation throughout the entire project.*

The overall rating of their group members' participation was also high (**Figure 16**).

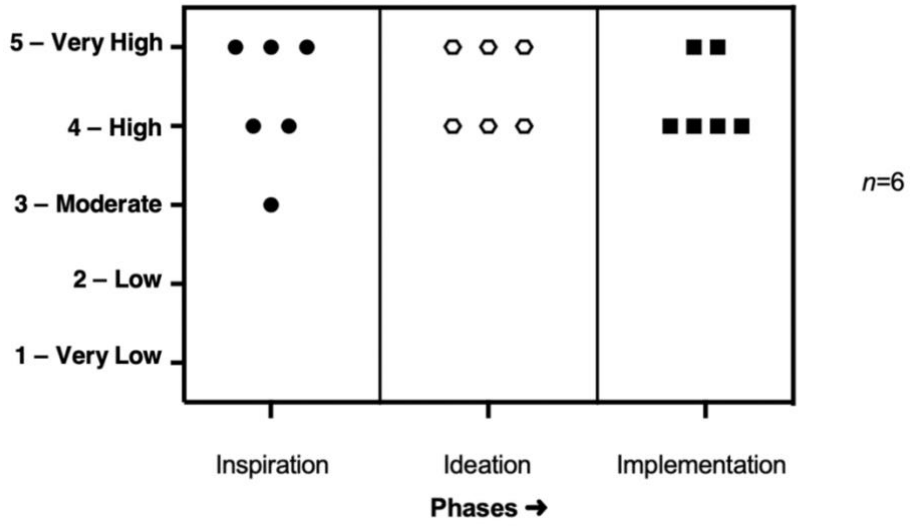

Figure 16 *Rating of group members' participation throughout the entire project.*

On these rating scales, the rating score for "Moderate (Decision-making was partly shared; group leader had the final say)" – posed some uncertainty for the participants when completing the questionnaire:

> *"Was there actually a group leader?"* (Participant 6)

Participants were uncertain to whom the term group leader referred; students in the course, the course facilitators, or the course lecturer.

Since the group has no appointed or selected leader among the students, and since the individual student's participation is being assessed, the "group leader" phrase was removed, and a revised item (applicable to all rating scales) was included in the questionnaire:

Please complete the scale to rate your own participation throughout the [ ] phase

1 – Very Low (I did not participate in any decision-making)

2 – Low (I participated in few decision-making activities)

3 – Moderate (Decision-making was partly shared)

4 – High (I participated in most of the decision-making activities)

5 – Very High (I participated in all of the decision-making activities)

4.2 Written reports

In addition to the questionnaire responses, the written reports were used as a data collection tool to identify any elements of engagement that may have been missed in the questionnaire items. This information was used to validate or adjust the initial questionnaire items.

4.2.1 Physical engagement

Physical engagement is related to the participatory nature of the activity and requires participants to invest physical energy to achieve tasks and milestones. These tasks involve activities completed in the classroom, as well as outside the confines of the classroom.

Several activities pertaining to physical engagement were evident in the written reports, including:

- Generating a stakeholder map
- Site visits for data collection, including observations and interviews, and prototyping
- Using post-it notes to understand information
- Attending an interview course and practice sessions
- Creating prototypes and mock-ups of ideas
- Using LEGO® blocks to create models of ideas
- Role playing during prototype testing
- Consulting external organisations such as the Community Health Intervention Programmes (CHIPs) in Cape Town, for assistance with the development of a physical activity intervention for older persons.

4.2.2 Emotional engagement

Emotional engagement was related to the motivation and interest in the activities that were undertaken to achieve milestones throughout the project. The reflective component of the written reports was used to review the emotional engagement throughout the learning process.

Several academic emotions – which are emotions that influence cognition and performance and are linked to learning and achievement in an academic context (Pekrun et al., 2002) – were evoked as a result of activities undertaken in the classroom and while interacting with stakeholders (feedback during testing and prototyping). These emotions are presented in **Table 4**.

Table 4 *Academic emotions identified in the written reports. The table scaffold is adapted from Pekrun et al. (2002).*

	Positive	**Negative**
Process	Enjoyment	Boredom
Prospective		Being frightened
Retrospective	Feeling of success Liking Satisfaction Excitement Amazement	Disheartenment
Social	Gratitude Confidence	

Several of these emotions, particularly the positive emotions, were tested in the emotional engagement questionnaire item for the ideation phase. However, the negative emotions were not tested in the initial questionnaire; since emotions can affect attention, motivation and modulate thinking (Pekrun et al., 2002) it might be useful to assess these negative emotions more explicitly in the questionnaire as with the positive emotions. The negative emotions present in the written reports are reported by Pekrun et al. (2002) as examples in the domains of academic emotions.

To revise the questionnaire, two items were added to test negative emotions during each phase of the project:

1. *I experienced negative emotions (boredom, disheartenment, anxiety, antipathy etc.) during the [ ] phase of the project* (Likert scale)

2. *How did these negative emotions affect your participation in the activities undertaken in this phase of project?* (Narrative) This item will provide insight on the consequences of the negative emotions that may be experienced during the project phases.

4.2.3 Cognitive engagement

There were many instances when physical engagement and cognitive engagement coincided. For example, generating a stakeholder map requires both cognitive and physical engagement as students would need to think about the information that was collected and to write it down on a post-it note and paste the notes on a board. The following cognitive engagement tasks were evident in the written report:

- Continuous decision-making
    - This involved elements of decision-making on questions for interviews, reframing a point of view, development and creation of ideas and prototypes, as well as the final prototype for the final presentation.

- Development of interview questions
    - This was done prior to meeting with and interacting with stakeholders for the purpose of data collection.
- Unpacking, understanding data, and defining personas, through activities such as:
    - A mindwash
    - “we met…”, “they told us…”, “we should have asked…”
    - Connections Contradictions Tensions and Surprises
    - “we met…”, “they told…”, “this is surprising because…”, “wonder if it means…” “they need a way…”

  These activities assisted in understanding the users and their context so that relevant ideas and prototypes could be generated.
- Development of a *point of view* that guided Ideation
    - This involved reframing a challenge statement based in new insights and information collected through stakeholder engagement.
- Reviewing relevant literature
    - The aim of the literature review was to identify and understand the various design thinking toolkits available in the literature.
- Brainstorming and generating ideas
    - Primarily a classroom activity, these activities were based on insights and the drive to achieve social change in the form of a solution.
- Assessing the strengths and weaknesses of ideas

Instances of cognitive engagement in the written reports were framed in a positive manner, suggesting a valid link to the high rating of participation for both individual and group rating as physical engagement and cognitive engagement often coincided.

4.3 Focus group

This section provides general information on the questionnaire not addressed in **Section 4.1**.

General questionnaire layout

Despite the questions for each phase of the project being sectioned in the initial questionnaire, it was recommended that each section should have a description detailing explicitly which phase the items relate to:

> *"Something that might help is to put on the headings…maybe next to it, answer all of these questions specially in relation to the activities you undertook during [each phase]"* (Participant 2)

In addition to the descriptors clarifying information required for each phase, participants agreed each phase must have a separate questionnaire. This would help with the accuracy and detail of the information recall:

> *"Because sometimes you don't even remember what was in that phase."* (Participant 1)

To revise the questionnaire, these recommendations were incorporated into the updated questionnaire; each phase of the project features an instruction explicitly informing the respondent that items in that section relate only to the respective phase, and each phase will be a separate questionnaire completed in isolation soon after much of the activity for that phase has been completed.

External collaborations

During the course of the project, one group consulted an external organisation for assistance. However, the group did not physically interact with the organisation themselves like they did with other stakeholders:

> *"The problem is we didn't do it; it was through our facilitator."* (Participant 6)

Participants thought that they could have received more information which could have been useful for their design. While interacting with this organisation as a stakeholder may have enriched their experience in the course, not all activities are conducted by the students without any assistance from the course lecturer or facilitators.

Item exclusions

There were no questions that participants thought should be removed, only that some needed to change as described in **Section 4.1**.

4.4 Practitioner validation

Three practitioners (the course lecturer and two facilitators) assessed the updated questionnaire, after revisions emanating from the responses to the initial questionnaire.

4.4.1 Inspiration phase items

Practitioners rated physical and cognitive engagement items as able to elicit sufficient information from respondents; all practitioners rated the items 4 on a five-point Likert scale. Thus, the updated questionnaire items for physical and cognitive engagement were not revised following practitioner validation.

For the emotional engagement items, one practitioner rated 3, while the other two rated 4; it was explained that questions on the identification of stakeholders could cause some confusion as:

> *"Primary stakeholders were not identified by the students as this is done before they arrive the classroom. Because this is the design thinking methodology applied to classroom, not all aspects of DT [Design Thinking] would have been left up to the students, for logistical reasons."* (Practitioner 3)

This explains why one group did not physically interact with CHIPs themselves like they did with other stakeholders. It also explains why students struggled to provide an appropriate answer to the question *How were the project stakeholders identified?* Only three respondents provided an answer that was unequivocally behavioural, while the rest struggled due to confusion and broadness of the question which incited "lots of speculation" about what a suitable answer would be.

Since it is unknown whether other institutions identify primary stakeholders for students too, the updated questionnaire items for emotional engagement were not revised following practitioner validation; questionnaire respondents may provide an answer stating that in some cases the stakeholders were not identified by them but by the course lecturer/s and/or facilitators. Such an answer is valid as it provides information about how activities were conducted in the project.

4.4.2 Ideation phase

Practitioners rated physical and emotional engagement items as able to elicit sufficient information from respondents; two practitioners rated 4 while one rated 5 for the physical engagement items, and all rated 4 for the emotional engagement items, on a five-point Likert

scale. Thus, the updated questionnaire items for physical and emotional engagement were not revised following practitioner validation.

For cognitive engagement, two practitioners rated 4 while one rated 2; it was explained that

> *"Literature was assigned to bolster understanding of design thinking, but specifically reading up on ideation would not have occurred and would not have been recommended."* (Practitioner 3)

In the focus group, the students confirmed that they had been expected to read literature on design thinking, however not on the project topic. While they were not required to read literature beyond design thinking methodology, the one student who did engage in literature related to the project topic (**Figure 11**) may be explained by achievement emotions which affect intrinsic motivation i.e. interest or curiosity in academic activities. Specifically, positive emotions can bolster intrinsic motivation (Pekrun et al., 2011). It is therefore crucial that, in addition to assessing emotional engagement, cognitive engagement be assessed to understand possible links between emotional and cognitive engagement. As such, the updated questionnaire items for cognitive engagement were not revised following practitioner validation.

4.4.3 Implementation phase

Practitioners rated physical (two rated 4 and one rated 5), emotional (all three rated 4), and cognitive (a rating of 3, 4, and 5) engagement items as able to elicit sufficient information from respondents. However, there was a concern with the wording for one of the items:

> *"I wouldn't agree with the term used "novel solution". A first iteration of design thinking will probably not yield a fully functional solution."* (Practitioner 3)

To revise the item, the word *novel* was removed.

The updated questionnaire, incorporating all the analysis that has been presented, is provided in the **Appendix**.

5 Discussion

The aim of this study was to develop an assessment framework to assess student engagement in design thinking projects for health innovation. Qualitative methods were employed to develop and administer a questionnaire for preliminary assessment. Students' written reflective reports on the course were analysed. A focus group was conducted to gather information about the questionnaire and to revise it. In addition, design thinking practitioners were consulted for validation of the revised questionnaire.

5.1 Questionnaire design

To design the questionnaire, the questionnaire development guide by Gehlbach, Artino & Durning (2010) was applied. The aspects of engagement were conceptualised based on the Burch Engagement Survey for Students (Burch et al., 2015); these correspond with the definition of student engagement proposed by Sharan (2008).

There are several key features of the current study that are unique and are reflected in questionnaire items absent in other instruments designed to assess student engagement:

- This questionnaire is aimed at assessing engagement in design thinking projects for health innovation. Typically, instruments to assess student engagement do not consider the multi-environmental and engaged pedagogy of the design thinking method. Although the end-of-course evaluation of the Public Health Innovations course at the University of California – which applies design thinking – contains elements of cognitive engagement, the items are not in the context of the application of design thinking for pedagogy in which students engage with community stakeholders (Sandhu, Hosang & Madsen, 2015). To bridge this gap, our questionnaire items specifically assess engagement amongst students as well as their engagement with community stakeholders – this can provide an understanding of student engagement beyond classroom activities which tend to be theoretical in nature.

- We have approached the development process through triangulation of data collected using various tools. Initially, the questionnaire items were synthesized using previous literature on participatory health research and student engagement – these items were administered to students of the Health Innovation & Design course at the University of Cape Town. In addition, the students' written reports were analysed for further evidence of engagement. The items were then revised following a focus group discussion with the students about the relevance of the items and whether or not they

were understandable and captured student experiences in the course sufficiently. Design thinking practitioner validation of the revised questionnaire followed; similarly to Visser et al. (2019), three practitioners ("experts") contributed to validation of the questionnaire items.

- The questionnaire combines various types of items i.e. narrative, closed, and Likert scale. Typically, instruments solely apply quantitative measures to assess either student engagement or participation in health research projects. For example, Hopper (2016) recently applied an instrument developed by Ahlfeldt, Mehta & Sellnow (2005) to assess student engagement in various physiology courses at university level. This instrument, based on the NSSE, applies quantitative measures.

- The questionnaire addresses student engagement holistically, incorporating physical, cognitive and emotional aspects of engagement. To assess participation in design thinking projects, Hendricks et al. (2018) have modified previously used instruments into a mixture of qualitative guide questions and rating scales. A limitation of the Hendricks et al. (2018) instrument and those on which it was based, is that they do not assess student engagement holistically, nor do they simultaneously integrate the involvement of the community in the generation of innovative health solutions.

5.2 Student Engagement

The concept of student engagement in an educational setting – which involves physical, emotional, and cognitive engagement – was applied to the health research setting in which participation, i.e. physical engagement, is typically the primary focus. A limitation of only assessing participation is that the antecedents of student engagement are largely ignored thus limiting the potential to enhance engagement. To overcome this limitation, we sought to combine several definitions to assess engagement more holistically.

In accordance with the definition commonly used in educational research, this study has sought to apply the term *(student) engagement* – which encompasses physical, emotional, and cognitive elements – to the broader context of health research that involves the community as stakeholders for co-creation of health solutions. As such, *participation* and *engagement* have not been used interchangeably to mean the same thing.

Assessment tools for student engagement can provide an understanding of how and why students engage in academic tasks, elucidating the antecedents of academic and

achievement emotions. These emotions are experienced when a student feels in control, or out of control, of activities and/or their outcomes (Pekrun et al., 2011). Pekrun et al. (2011) explain that a perception of control affects the actions of students, i.e. “academic effort”, which will be related to the expected outcome i.e. “good grades”.

In the context of design thinking, these antecedents are multifaceted and may differ according to activities undertaken in each of the phases of a project. For example, eagerness to learn new ways of conducting a needs or situational analysis might trigger positive emotions which then induce subsequent appropriate actions towards execution, and a positive outcome. Although only preliminary (as a draft questionnaire was used), our data support this as the participants rated enjoyment of project activities during the inspiration phase, positive emotions during the ideation phase, and pride in their final product, highly. It is expected that a student will enjoy academic participation when there is perception of competence and related material is interesting, while boredom arises when related material or activities are deemed to lack value (Pekrun et al., 2011).

Cognitive engagement was limited in our data as only one respondent read additional material related to the design challenge (**Figure 10** and **Figure 11**), despite the students’ pride in their work. The nature of the course may explain this finding, as students engaged with literature provided in the course for acquaintance with the methods of design thinking; they did not seek additional literature to assist with ideation and implementation of the product/solution.

5.3 Limitations

A small sample of the Health Innovation and Design course cohort for the 2019 year participated in the study. A small sample size limited quantitative analyses and precluded the use of statistics such as Cronbach’s alpha, which is commonly used to test internal consistency when developing similar assessment tools. While it may be recommended that these results are interpreted with caution as this study was a single institution/challenge study and that the psychometric quality of the questionnaire items was not tested, triangulation of data and practitioner validation strengthen confidence in the results of the study.

5.4 Conclusions

The study developed an assessment framework for student engagement in design thinking projects for health innovation. The questionnaire items are a mixture of narrative, closed, and Likert scale items. The questionnaire is aimed at holistic assessment of student engagement, addressing physical, cognitive and emotional engagement, and addresses shortcomings in

available assessment methods. This questionnaire may be used to assess engagement in academic settings as well as non-academic settings when design thinking is applied for health innovation. In both these settings, reflective journals could be applied and assessed to further identify and understand the phenomenon of (student) engagement, how the various aspects of engagement interact, and how they influence participation.

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Appendix

Updated questionnaire

	Question	Type
	Inspiration Phase Questions in this section relate only to the inspiration phase of the project.	
1	How were the project stakeholders identified?	Narrative
2	How were stakeholder needs/challenges identified?	
3	What was your role during this phase of the project?	
4	I enjoyed the participatory techniques of collecting information during class time in the inspiration phase.	Likert scale
5	I enjoyed the participatory techniques of collecting information when interacting with stakeholder during the inspiration phase	
6	I experienced negative emotions (boredom, disheartenment, anxiety, antipathy etc.) during the inspiration phase of the project.	Likert scale
7	How did these negative emotions affect your participation in the activities undertaken in this phase of project?	Narrative
8	Do you think that the interactive methods of collecting information during the inspiration phase enhanced your ability to successfully identity all the relevant stakeholders?	Closed (yes/no)
9	Please provide a reason for your answer in the previous question.	Narrative
10	Do you think that the interactive methods of collecting information during the inspiration phase enhanced your ability to successfully identity relevant stakeholder challenges?	Closed (yes/no)
11	Please provide a reason for your answer in the previous question.	Narrative
12	Prior to meeting the community stakeholders, my team planned how to collect the data to enable us to collect as much information as possible.	Likert scale
	Ideation Phase Questions in this section relate only to the ideation phase of the project.	
13	Please describe your contribution during the ideation phase of the project.	Narrative
14	I was positive (i.e. enthusiastic, excited, energetic, interested) about the activities that we undertook during the ideation phase of the project.	Likert scale
15	I experienced negative emotions (boredom, disheartenment, anxiety, antipathy etc.) during the inspiration phase of the project.	Likert scale
16	How did these negative emotions affect your participation in the activities undertaken in this phase of project?	Narrative
17	Did you read any material on design thinking or literature related to the project topic to help you with generating ideas during the ideation phase?	Closed (yes/no)

18	Please provide a reason for your answer in the previous question.	Narrative
19	Did you read any material on design thinking or literature related to the project topic to help you to create prototypes during the ideation phase?	Closed (yes/no)
20	Please provide a reason for your answer in the previous question.	Narrative
21	When my team was generating ideas, I stopped to ask myself whether or not I/we understood the information that we collected in the inspiration phase.	Closed (yes/no)
Implementation Phase Questions in this section relate only to the implementation phase of the project.		
22	What was your contribution during the implementation phase of the project?	Narrative
23	I am proud of our final product of the project.	Likert scale
24	Please provide a reason for your answer to the previous question.	Narrative
25	I experienced negative emotions (boredom, disheartenment, anxiety, antipathy etc.) during the implementation phase of the project.	Likert scale
26	How did these negative emotions affect your participation in the activities undertaken in this phase of project?	Narrative
27	I think that the participatory/interactive nature of design thinking was useful for my team to generate, plan, and produce a solution.	Closed (yes/no)
28	Please provide a reason for your answer to the previous question.	Narrative
Rating scales		
Self-rated	Please complete the scale to rate your own participation throughout the [ ] phase 1 – Very Low (I did not participate in any decision-making) 2 – Low (I participated in few decision-making activities) 3 – Moderate (Decision-making was partly shared) 4 – High (I participated in most of the decision-making activities) 5 – Very High (I participated in all of the decision-making activities)	Rating scale
Rating group member	Please complete this scale to rate the participation of your group members throughout the [ ] phase. 1 – Very Low (My group members did not participate in any decision-making) 2 – Low (My group members participated in few decision-making activities) 3 – Moderate (Decision-making power was partly shared) 4 – High (My group members participated in most of the decision-making activities) 5 – Very High (We all participated in all of the decision-making activities)	Rating scale